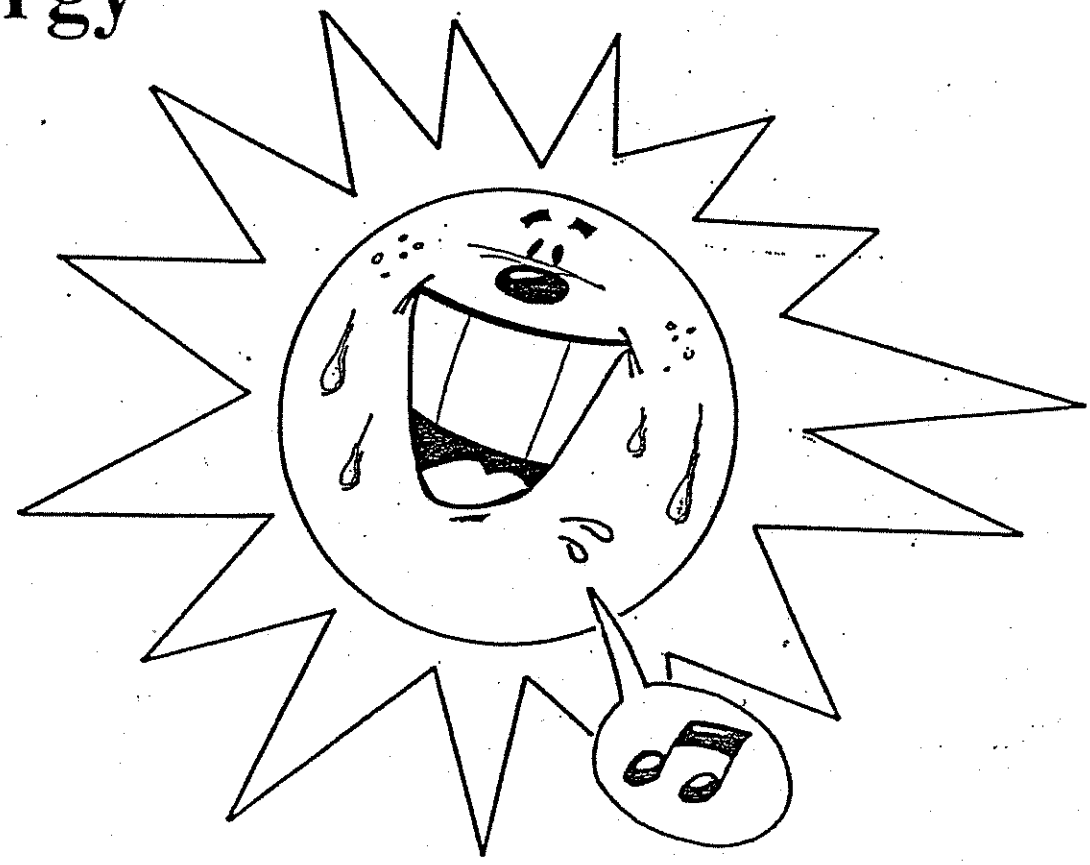
Classroom Exercises for Capturing the Sun's Energy



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Contents

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How to Build the Parabolic Trough Hot Dog Cooker

How to Build the Flat Plate Solar Collector

How to Obtain the Dish/Sterling System

Flash Cards

Video

Flat Plate Collector; Experiment #1

Time	Temp. F (Covered)	Temp. F (Uncovered)
0 (start)		
5 min.		
10 min.		
15 min.		
20 min.		
25 min.		
30 min.		

Flat Plate Collector; Experiment #2

Time	Temp. F	Temp. F
	black	white
0 (start)		
5 min.		
10 min.		
15 min.		
20 min.		
25 min.		
30 min.		

Flat Plate Collector

Experiment #3

Does the angle that a collector makes with the ground determine how fast the collector heats up?

Materials

- Four flat plate collectors
- Four metal meat thermometers (range 50° F to 180° F)
- Watch or clock

Hypothesis

Write what *you* think is true.

_____

_____

_____

_____

Procedure

1. During the middle part of a sunny day, place four collectors side by side outside on the ground and insert a thermometer in each one, under the metal plate (make sure that the plates all have the same color metal plate face up and are covered entirely).

2. Let one collector remain flat on the ground. Using wood or books and a protractor, incline each of the three remaining collectors at a different angle. Record these angles on your data table (suggested angles are 0°, 15°, 30°, and 45°). Make sure that all the collectors are tilted up toward the sun.

3. Record the temperature that you observe in each flat plate collector in the data table. Record the temperature when you start and every 5 minutes afterward for 30 minutes.

4. Repeat the experiment at different times of the year, such as September, December, and May; record and compare the results.

Data

Time (minutes)	Temperature (°F) At Angle # 1=0°	2= °	3= °	4= °
0 (Start)				
5				
10				
15				
20				
25				
30				

Conclusions

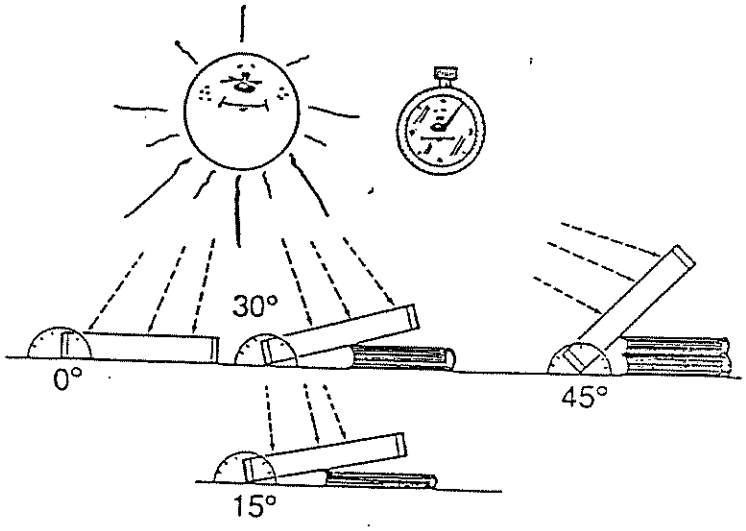
What does your data tell you about collecting the sun's energy? At what angle does the collector do a better job? How do the collectors perform at different times of the year? What does this tell you about the importance of the tilt?

_____

_____

_____

_____



Refractive Concentrators

Experiment #1

Is a magnifying glass or a Fresnel lens better at concentrating light?

Materials

- Hand-held magnifying glass (make sure it is about the size of the Fresnel lens)
- Small Fresnel lens (make sure it is about the size of the magnifying glass). Fresnel lenses can be purchased through most educational materials catalogs.
- Bucket of water (1 to 2 gallons) or active garden hose
- Two pair of leather work gloves or oven mitts
- Paper

Hypothesis

Write what *you* think is true.

_____

_____

_____

_____

CAUTION:

- Always use the water to completely extinguish the fire on the paper at the end of the experiment
- Always wear gloves.
- Keep observers at a safe distance.
- *Do not* allow students to play with the lenses (such as focusing sunlight on themselves or each other).

Procedure

1. Choose an outdoor location in an open area that has no nearby combustible materials. Make sure that the bucket of water or hose is nearby so that you can extinguish any small fire that you make with the lenses.
2. On a sunny day, set the paper and lenses in sunlight.
3. Select two students and have them put on the gloves or mitts. Give one the magnifying glass and the other the Fresnel lens. Have them both focus the lenses on the paper at same time.
4. Record which paper burns first as a result of this trial.
5. Repeat these steps at least three more times and record what happens each time in the data table.

Data

Trial	Quickest burn (magnifier or Fresnel)
1	
2	
3	
4	

Conclusions

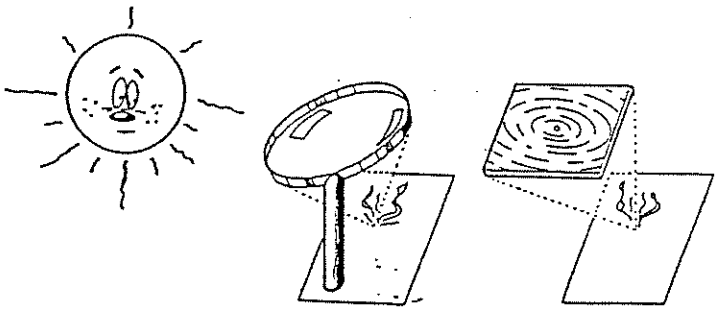
What does your data tell you about concentrating the sun's energy? Which lens, the magnifier or Fresnel, burns the paper more quickly?

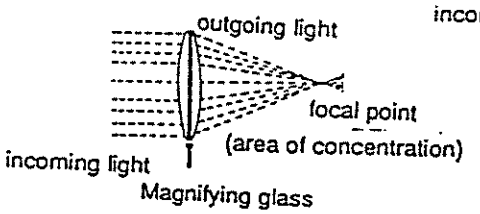
_____

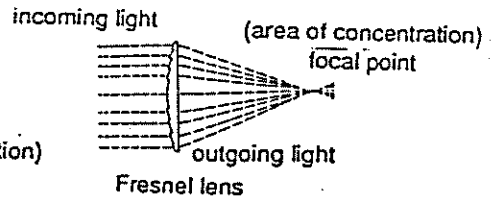
_____

_____

_____







Refractive Concentrators

Experiment #2

Is a larger magnifying glass better at concentrating light than a smaller one?

Materials

- Hand-held 3-inch (or larger) magnifying glass
- Black or dark heavy construction paper or cardboard (1 sheet)
- Black or dark lightweight paper (1 sheet)
- Scissors
- Watch or clock
- Bucket of water (1 to 2 gallons) or active garden hose
- One pair of leather gloves or oven mitts

Hypothesis

Write what *you* think is true.

_____

_____

_____

_____

CAUTION:

- Always use the water to completely extinguish the fire on the paper at the end of the experiment.
- Always wear gloves.
- Keep observers at a safe distance (5 to 10 feet away).
- *Do not* allow students to play with the lenses (such as focusing sunlight on themselves or each other).

Procedure

1. Choose an outdoor location in an open area that has no nearby combustible materials. Make sure that the bucket of water or hose is nearby so that you can extinguish any small fire that you make with the lenses.
2. On a sunny day, set up the lightweight paper and lens in sunlight to find the best position to make the paper burn. Record the time it takes in the data table.
3. Cut a 2-inch hole in the construction paper and cover the lens with the paper so that the hole is over the lens (this turns the larger lens into a smaller one).
4. Repeat Step 1. Now how long does it take for the paper to burn?
5. Repeat these steps with different sized holes.

Data

Hole size	Time to burn (seconds)
Uncovered	
2-inch	
1-inch	
1/2-inch	

Conclusions

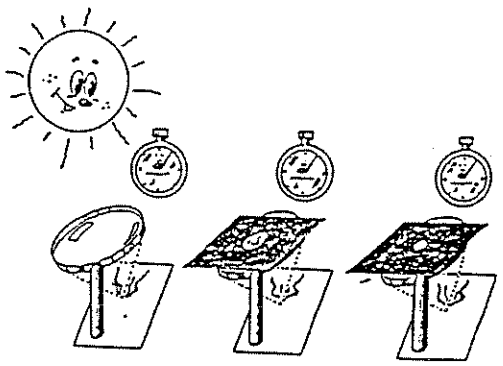
What does your data tell you about concentrating the sun's energy? Which lens, the larger or smaller, burns the paper more quickly?

_____

_____

_____

_____



Refractive Concentrators

Activity

In this activity, you will compare a magnifying glass and a Fresnel lens. Fresnel lenses can be purchased through most educational materials catalogs.

To the teacher: *Do this activity indoors to avoid accidental burning.*

Set out magnifying lenses and Fresnel lenses for the students to handle. Remind the students that these refractive concentrators let light pass through them and bend the light rays as they come out to make them come together at a focal point.

To the student: Look over, handle, and touch the surfaces of the two types of lenses. Then answer the following questions.

1. Tell what you think each lens is made of.

   The magnifying lens seems to be made of_____

   The Fresnel lens seems to be made of _____

2. Compare the surface of the magnifying lens to the surface of the Fresnel lens.

   _____

   _____

3. Describe a Fresnel lens so that someone looking at a pile of different things could pick out the Fresnel lens in the pile._____

   _____

4. How do you think the magnifier could be improved?_____

   _____

5. What kind of problem would a much larger magnifier have?_____

   _____

6. Why is a plastic Fresnel lens probably better to use than a glass one?

   _____

Reflective Concentrators

Activity #2

In this activity, you will use a dish/Stirling engine. You, the teacher, or another adult will perform all steps in this activity; do not allow students to play with this device.

CAUTION:	The concentrator creates high temperatures and very bright light at the focus. Make sure that you or another adult wear heat-proof gloves while demonstrating the model. All other observers should be kept at a safe distance (5 to 10 feet away).

To the teacher: Let students examine the dish Stirling engine. An engine converts energy into motion; the dish Stirling engine converts solar energy into motion.

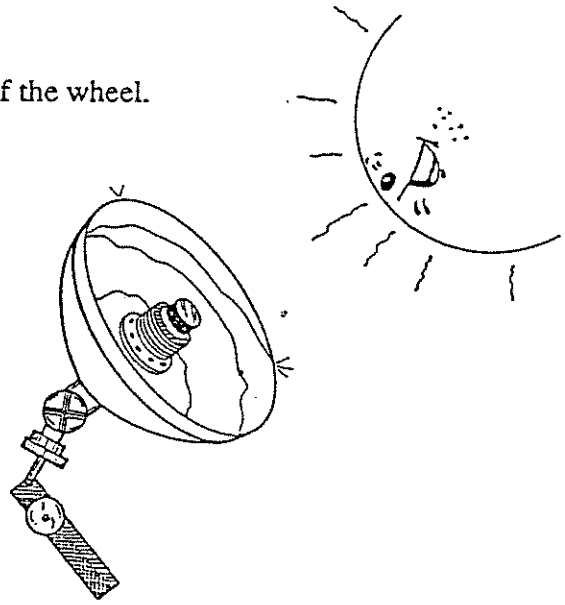
Identify:

1. The reflective surface, which is called a dish reflector.
2. The surface upon which the light will focus (this will be heated up).
3. The wheel behind the reflective dish, which will move.

With hands protected by heat-proof gloves, the teacher or another adult should hold the dish as shown in the videotape and aim the dish toward the sun. When the dish is properly aimed, the central spot in the dish will shine brightly.

Spin the wheel to start the engine working.

Change the aim of the dish and observe changes in the speed of the wheel.



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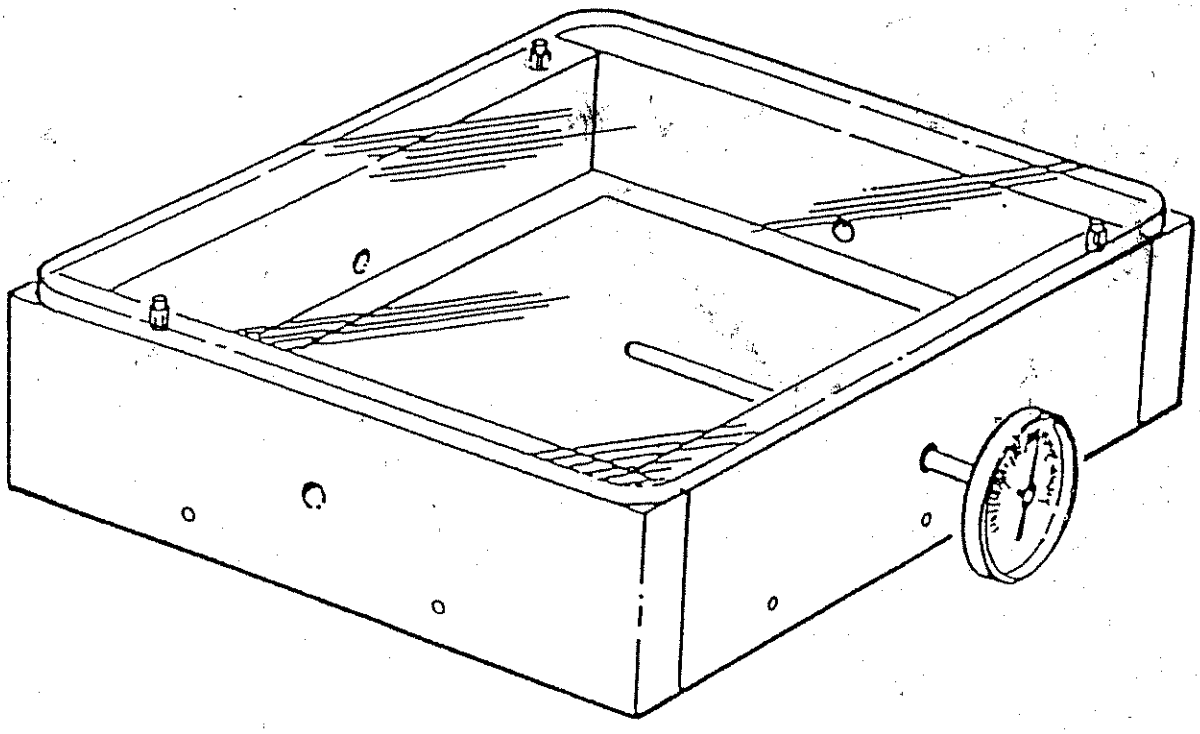
How to Build the Flat Plate Solar Collector Model



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Background

The small plastic-covered models demonstrate flat plate solar collectors. The model consists of a simple wooden open-top box, a transparent top, and a painted slab of metal (black on one side, white on the other).

For the classroom exercises, you will also need a metal meat thermometer that can measure temperature in the range of about 50°F to 180°F. To do all the experiments in the classroom exercises, you will have to construct a total of 4 collectors because Experiment 1 calls for 2 collectors, and Experiment 3 calls for 4 collectors.

How it works

The transparent top allows the sun's rays into the box. When the sun's rays strike the metal plate, the metal plate heats up. This heat is then trapped inside the box by the transparent top. You can measure this heat buildup over time with the thermometer.

What you will need to build it

Materials

4-quarter or 1-inch (nominal) thick pine or any medium hardness wood that is easy to cut

Wood screws or nails

Construction glue (optional)

A piece of any clear plastic material (Plexiglass, for example) that is less than 5/16 inch thick

A piece of thin flat metal no less than 1/8 inch thick (scrubbed with sandpaper or steel wool so that it can take the paint) with no sharp edges

Any medium- to high-temperature flat enamel paint, black and white (can also use black and white auto paint if you have any to spare)

Tools

Saw or table saw

Hammer or screwdriver

1- to 3-inch paint brush, roller, or foam rubber brush

How to build it

1. Cut the pieces as shown in Figure 1 (pg 5).

2. Construct the box as shown in Figure 2. You may glue, screw, or nail the box together. You should paint the box a light color or white.

3. Drill 1/4-inch holes in the side (1, 2, 3, or 4 holes) to allow the thermometer(s) in.

4. In a well-ventilated area, paint the metal slab black on one side and white on the other according to the paint manufacturer's directions (allow each side ample time to dry).

5. Line up the holes in the transparent top with the finishing nails that you placed on the box as shown in Figure 2 (pg 6) and place the top on the box (these nails keep the top from sliding off during tests): you are now ready to use the model.

How to test the model

Place the box outside on a sunny day and insert one or more thermometers through the hole(s). Make sure that the thermometer fits under the metal plate and that it can be read easily. Tip the model up about 30° from the ground: make sure that the top is properly secured on the nails and does not slide off.

Figure 1

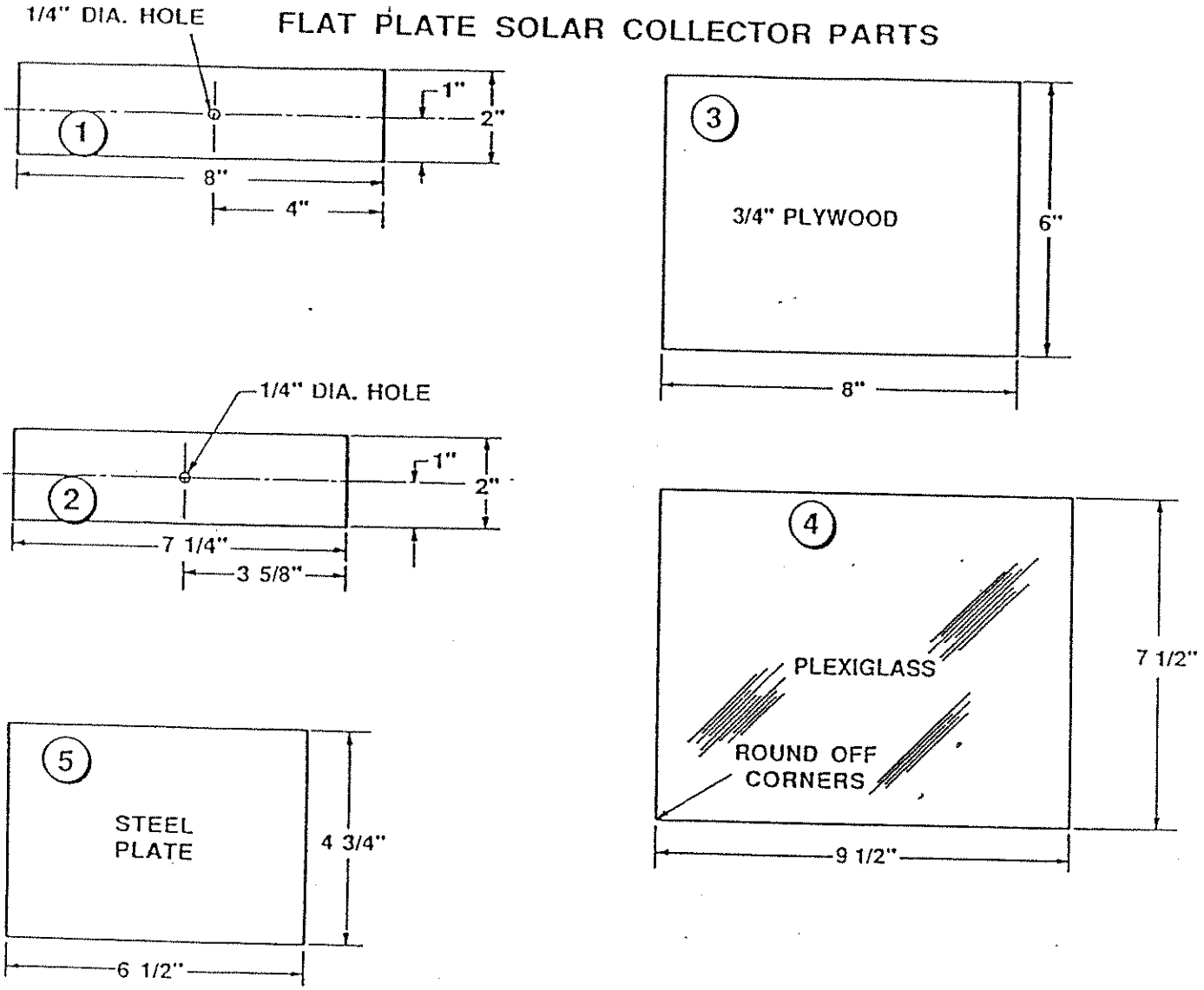
FLAT PLATE SOLAR COLLECTOR PARTS
1/4" DIA. HOLE
1
1"
2"
8"
4"
3
3/4" PLYWOOD
6"
8"
1/4" DIA. HOLE
2
1"
2"
7 1/4"
3 5/8"
4
PLEXIGLASS
ROUND OFF CORNERS
7 1/2"
9 1/2"
5
STEEL PLATE
4 3/4"
6 1/2"

Figure 2